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INFORMATION CIRCULAR

MINING METHODS AND COSTS AT THE TEZIUTLAN COPPER MINE OF THE MEXICAN CORPORATION, S. A., TEZIUTLAN, PUEBLA, MEXICO

RECEIVED

BY

ERNEST PH. HERIVEL

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MINING METHODS AND COSTS AT THE TEZIUTLAN COPPER MINE OF THE MEXICAN CORPORATION, S. A., TEZIUTLAN, PUEBLA, MEXICO[1]

By Ernest Ph. Hérivel[2]

LOCATION AND HISTORY

The mine and treatment plant of the Teziutlan unit of the Mexican Corporation, S. A., are located at Aire Libre, in the District of Teziutlan, near the northeast edge of the State of Puebla, Republic of Mexico. The property is leased from the Teziutlan Copper Co.

The town of Teziutlan is the terminus of a branch railroad starting from Oriental Junction on the Mexico-Jalapa-Veracruz narrow-gage system of the National Railways of Mexico. A branch line 18 km in length from Teziutlan to Aire Libre belongs to the Teziutlan Copper Co. and is leased and operated in conjunction with the mine.

Aire Libre is on the Mexican Gulf slope at an altitude of 4,800 feet above sea level, while Teziutlan is about 1,470 feet higher. Because of the heavy grades on the company railway it is necessary to use Shay geared locomotives for hauling supplies and concentrates between these two points.

Mining operations at this property commenced in 1892 upon the discovery of an outcropping body of copper ore of sufficiently high grade to stand the heavy cost of shipping by muleback and railroad to smelters in northern Mexico. Later a smelter with blast furnaces and converters was built near the mine, in which crude ore was smelted. As the mine workings deepened the presence of zinc in the ore began to affect the smelter operations so adversely that a roasting plant was constructed, and still later a mill and concentrating plant were put into operation in an attempt to eliminate the zinc. The first concentration scheme, consisting of a combination of tabling and bulk flotation, was successful for a time; but a continued decrease in the copper content of the ore, accompanied by an increase in zinc and iron contents, finally brought about the abandonment of this scheme in view of the impossibility of producing a concentrate of sufficient grade to smelt profitably.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6736."

[2] One of the consulting engineers, U. S. Bureau of Mines.

The property was closed down for a number of years until the advent of selective flotation when, after a considerable period of pilot-plant research, a treatment scheme was evolved which gave a satisfactory separation of the constituent minerals and produced marketable copper and zinc concentrates.

After the necessary additions had been made to the concentration plant, active operations were resumed in September 1925 and continued until December 1931, when the continued fall in the price of base metals brought about a complete shut-down.

GEOLOGY AND PHYSICAL CHARACTERISTICS OF THE OREBODIES

The orebodies, which are flat-lying lenticular deposits, are found in metamorphosed igneous and sedimentary pre-Cambrian rocks. Mineralization occurred after the period of metamorphism and is believed to be related to a later intrusion of dolerite. Other igneous intrusions are bostonite sills and dikes and an andesite dike.

Four ore bodies have been discovered at successive depths, which are called, respectively, Aurora, Cometa, Volcan, and Minerva. (See fig. 1). The prominent outcrop of the first led to the discovery of the mine; the others were located by diamond drilling. Numerous faults, mostly of pre-mineral age, are responsible for a considerable amount of displacement within the orebodies (fig. 2).

The Aurora and Cometa lenses have mica-schist footwalls and phyllite hanging walls; the Volcan and Minerva lenses have both walls of phyllite. The hanging wall of the Minerva is a soft grey phyllite, in contrast with a fairly hard, dark phyllite over the other bodies.

The ore is a massive sulphide, the principal minerals of which are chalcopyrite, sphalerite, pyrite, and galena, in a gangue of quartz and, occasionally, mica schist. There is some mineralization of the mica-schist footwall in certain sections of the Aurora and Cometa lenses, but in general the mineralization ends sharply at the contact of ore and wall rock. The lenses have a general east-west strike and dip toward the south. The dip is irregular, probably conforming with folds in the encasing rocks, and ranges from less than 20° to 65° in a few isolated cases; the average is approximately 35°.

The following tabulation gives the approximate size of the orebodies, excepting the Minerva, which is only partly developed:

Approximate size of orebodies (Minerva partly developed)

	Length		Height		Width	
	Meters	Feet	Meters	Feet	Meters	Feet
Aurora	370	1,210	270	890	3.6	11.8
Cometa	390	1,280	280	920	2.2	7.2
Volcan	230	750	140	460	2.2	7.2
Minerva	270	890	100	330	1.7	5.6

GENERAL STATISTICS

The normal daily tonnage during the last period of operations has been 220 tons per working day produced from the mine, and 180 tons daily milled.

The average grade of the ore is tabulated below in order to compare the whole last operating period with the year ending June 1931 and with the month of December 1931. The increase in zinc and lead is due to the production from the Minerva orebody, which started in January 1931. By the end of the year about 90 percent of the total tonnage mined was from the Minerva, the other orebodies being practically worked out.

	Gold, penny-weight	Silver, ounce	Copper, percent	Zinc, percent	Lead, percent
September 1925 to June 1931	0.585	2.677	3.27	11.92	1.20
July 1930 to June 1931	.685	3.159	3.20	13.82	1.72
Month of December 1931	.806	3.215	3.02	13.99	2.15

There are no data available regarding total production from earlier operations, but the following figures give this information for the years 1929 and 1930, and from September 1925 to the end of 1930.

	1929 and 1930	September 1925 to December 1930
Ore produced........................ tons	129,233	325,281
Copper in concentrates produced.....pounds	6,853,000	17,876,345

MINING

The mine is worked through an adit on the 160-meter level that was driven below the Aurora orebody and into the Cometa. When the workings in the Cometa extended below the adit level, an interior three-compartment shaft was sunk, from which the 190-meter and 220-meter levels were developed. Later this shaft was sunk to the 250-meter level where a crosscut was driven to the Volcan orebody. The exploitation of the lower levels of this orebody made necessary another smaller shaft to the 300-meter level. The discovery of the Minerva orebody, deeper and farther from the adit entrance, brought up more serious handling and ventilation problems and it was decided to sink a shaft from the surface about 1 mile from the tunnel entrance.

SHAFT

The Minerva shaft was sunk in 1930. It has three compartments, each 5 by 6 feet in the clear, timbered with 8- by 8-inch oak sets at 5-foot intervals and lagged with 2- by 12-inch oak plank. The guides are of treated pine, 4 by 8 inches in section. In two compartments single-deck cages are used for hoisting; the third is divided into two smaller compartments, one 2 1/2 by 5 feet for pipes and electric cables, the other for a ladderway.

Before starting shaft work the 180-meter, 250 meter, and 300-meter levels were driven to the shaft location, and from each level a pilot raise was put up; sinking from the surface commenced at the same time. After the pilot raises were broken through they were stripped to full size and timbered to the 300-meter level; from there the shaft was sunk full size for a further distance of 82 meters and the 370-meter level was opened, leaving a 12-meter sump. Fifty-pound jackhammers were used in sinking operations, and stoping drills were used in the pilot raises.

WINZES

Very little development is done by winzes, only two having been started, shortly before cessation of operations, to explore the Minerva orebody below the 370-meter level. These winzes are 5 by 8 feet in section, and are divided so as to leave the hoisting way 5 by 5 feet and the remaining space for ladders. They are sunk on the ore and the only timber required is for stulls and lagging between ladders and ore-pass. Hoisting is done with small tugger hoists, using round buckets of about 250-pound capacity running on timber skidways.

RAISES

Raises likewise are usually 5 by 8 feet in section, with a 5- by 5-foot chute at one end; 8- by 8-inch stulls and 2- by 12-inch plank lagging are used for separating manway and chutes. When the adjacent ground is stoped, additional stulls are placed at both ends and lagged on the outside with 3-inch poles.

DRIFTS AND CROSSCUTS

Drifts and crosscuts are driven 5 by 7 feet in the clear. Only about 10 percent of the workings in country rock require timbering, but in the drift on the Minerva orebody about 50 percent is timbered because of the softer hanging wall. Sets of 10- by 10-inch oak are used with 3-inch pole lagging overhead. Drilling is done with 130-pound drifting machines, using two to a face. In average ground a standard 17-hole round is drilled. All breaking is done with 40 percent strength gelatin dynamite in 1- by 8-inch sticks. Wherever possible electric blasting is used in development work.

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STOPING

The room and pillar method has been used generally in the first three orebodies. About 15 percent of the ore was left as pillars, spaced according to height of stope and condition of hanging wall. A section of the orebody, usually the length between fault slips or offsets, was worked out from a main level or sublevel to the next above, or to the top of the ore lens, after which pillars were mined, retreating from the outer or upper extremities, and allowing the back to cave in. If the pillars had been standing for a long time it was found advisable to use some additional form of support to prevent the roof from caving too fast as the pillars were removed. Between levels this was most easily accomplished by dry-walling and pack-filling sections of the stopes; where waste for filling was not available rows of stulls had to be put in before removing each successive row of pillars.

Main haulage levels are generally spaced at 30-meter (100-foot) intervals, but where the lenses flattened out, sublevels were put in to facilitate handling of ore from stopes. In some cases the ore was dumped through chutes to a main level below, and in others the cars were hauled up an incline to the level above by means of small hoists. Stope chutes were put in as convenient between pillars and the ore moved to these by shovel and wheelbarrow. Raises were run between levels only as required for roadways and ventilation.

The cut-and-fill method was adopted in the Minerva stopes because of the soft hanging wall. With this method raises are put up at 30-meter (100-foot) intervals along the level, and from these the first stope floor is broken by stope drifts between the raises, leaving a 5-meter (16-foot) pillar above the level. Alternate raises are run up to determine the upper limits of the ore, which has been found to extend 20 meters (66 feet) to 50 meters (164 feet) above the level, measured on the plane of orebody. The other raises are carried up as the stope advances and serve as ore passes. For purposes of ventilation, one raise has been driven to a connection with workings on the 300-meter level.

After the stope drifts are connected, they are stripped to the full width of the ore, and the back in a section between a raise and chute is broken down to a height of 12 feet. As soon as the broken ore is removed the section is filled with waste to a height of 7 feet. Each successive cut is 7 feet high, and is immediately followed by filling.

Where stopes are sufficiently straight, the ore is handled by scrapers set up at the chutes midway between the raises, and pulling alternately from either side, so that while one section is being stoped the other is being filled. Where the orebody is folded and the stope sections consequently crooked, wheelbarrows are used; in such cases the lower parts of the waste raises are used as additional ore chutes in order to shorten the distance that the ore has to be moved in the stopes. The filling is handled in the stopes by shovel and wheelbarrow. In the higher sections of stopes, scrapers are used to pull the ore down the chutes, as the dip is too flat to permit it to flow by gravity.

Waste for filling is obtained by breaking caving stations at the tops of raises above the orebody. When lower levels are worked the waste can be trammed directly to chutes for delivery to the workings below, and waste from development work also will be disposed of in this manner.

Very little timber is used for support in stopes. Beyond an occasional stull to hold up a slabby portion of the hanging wall, the consumption of timber in stoping is mostly for construction of chutes and for raise timbering.

The ore is broken by inclined back holes, using stoping drills. All drills not of the wet type are equipped with spray attachments to allay the dust.

UNDERGROUND TRANSPORTATION

End-dumping cars of 20-cubic-foot capacity are used for transportation of both ore and waste. From stopes to shafts the tramming is done by hand. The loaded cars are hoisted in cages to the main tunnel, where trains are made up and hauled to the mill bins or waste dumps by 4 1/2-ton electric locomotives of the overhead-trolley type. Before being dumped into the mill storage bins the ore is weighed on track scales. The mine track is of 20-inch gage; 16-pound rails are used on all levels except the main tunnel, where 45-pound rails discarded from the railway have been put into service.

COMPRESSED AIR, VENTILATION, DRAINAGE, AND SAFETY

The compressor plant, consisting of four compressors with a total rated capacity of 3,200 cubic feet of free air per minute, is located at the entrance to the main tunnel. The air is delivered to the mine through a 6-inch pipe line, from which 4-inch lines are run off on the levels; further subdivision to stopes and working faces is through pipes of different smaller sizes, according to the number of machines served. The blacksmith and drill-sharpening shop is near the compressor house. Leyner drill sharpeners are used.

Natural ventilation through surface raises was sufficient for working the Aurora and Cometa orebodies. To remove the vitiated air and smoke from the Volcan workings, 11-inch rigid tubing was installed along the 250-meter level; exhaust fans were installed where needed, one being placed midway along the tubing as a booster. Propeller fans with stationary guide vanes were used in development headings. After connections were made with the Minerva shaft, natural ventilation supplied all needs except in the case of long drifts. The mine is naturally cool, and the temperature rarely exceeds 70°F.

Drainage and pumping are important at this mine. To handle water from the lower Cometa and upper Volcan workings, a three-stage centrifugal pump is installed at the 250-meter level and pumps to the tunnel level. It is driven by 75-hp. motor and has a capacity of 800 gallons per minute for a 300-foot lift. Water from the lower section of the Volcan orebody is collected at the 300-meter level and pumped to the 250-meter level by a 300-gallon, 125-foot lift, centrifugal pump driven by a 25-hp. motor.

A greater flow of water was naturally expected from the deeper workings, and a 4-stage centrifugal pump of 1,000 gallons per minute capacity, 800-foot lift, driven by a 300-hp. motor, was installed at the 370-meter level to pump directly to the tunnel level.

There is a considerable seasonal variation in the flow of mine water; surface infiltrations cause a marked increase, even in the lowest workings, soon after the commencement of the rainy season. The average flow of mine water varies from 650 gallons per minute during the months of March to May to 1,500 gallons per minute in September and October, fluctuating between the high and low points during the remainder of the year.

Three five-man crews are trained in the use of oxygen-breathing apparatus for rescue work, besides which weekly classes are given in first-aid and safety measures. First-aid kits are kept at easily accessible points throughout the mine, and gas masks are kept at different places in the lower levels, where they can be quickly found in case of emergency. The use of protective or "hard-boiled" hats is compulsory underground. The company maintains a well-equipped hospital, with doctor and nurse in attendance, for the care of injured workmen.

POWER

Power is generated at two company-owned hydroelectric plants, with a capacity of 2,430 kilovolt-amperes, situated about 7 kilometers from the mine. Sixty-cycle alternating current is generated and delivered to the property at 5,000 volts; transformer stations are located at the tunnel entrance for compressors, haulage, and mill service; and at the Minerva shaft for hoists and pumping. All motors are 440-volt, but for lighting and shaft signals the power is stepped down to 110 volts in small transformers.

COSTS

The following tables give detailed costs of underground operations, both in dollars (United States) and in units of man-hours and supplies; they cover the period from July 1930 to June 1931. The tonnage is that actually milled, as all costs are calculated on this basis. The differences between tonnage mined and that milled is negligible in a period of 12 months. Weights are in dry tons of 2,000 pounds.

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Table 1.--Summary of costs

Tons of ore mined during period: 65,764 Period: July 1930 to June 1931, inclusive

Mining methods: Open stope and pillar, cut and fill

Underground costs per ton of ore mined

	Labor	Supervision	Compressed air, drills, and steel	Power	Explosives	Timber	Other supplies	Total
Development	$0.458	$0.025	[1] $0.135	$0.008	$0.119	$0.068	$0.113	$0.926
Stoping	.877	.041	.252	......	.216	.107	.078	1.571
Transportation ..	.209	......	....	.008	....	....	.052	.269
General underground expense .	.152	.070	....	[2] .070	....	....	.020	.312
Surface expense (directly applicable to underground operation)	.080	......	....	......	....	....	.030	.160
Total	1.776	0.136	0.387	0.086	0.335	0.175	0.343	3.238

[1] Includes power for air compression.
[2] Principally power for pumping.

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Table 2.--Detail of costs in units of labor, power, and supplies

Tons of ore mined: 65,764
Mining methods: Open stope and pillar, cut and fill
Period: July 1930 to June 1931, inclusive

	Development	Mining	Total
Labor (man-hours per ton):			
Breaking (drilling and blasting)	0.449	1.068	1.517
Timbering	.104	.386	.490
Filling	.....	1.056	1.056
Shoveling	.631	1.788	2.419
Haulage and hoisting	.562	3.097	3.659
Supervision	.085	.293	.378
Pumpmen and mechanics	.....	.....	1.054
Storekeepers and tool changers	.....	.....	.267
Miscellaneous underground	.....	.....	.114
Total labor underground	.....	.....	10.954
Surface labor directly chargeable to underground operations	.....	.....	1.027
Average tons per man per shift	.....	.....	.674
Labor, percentage of total cost	58.2	71.2	69.4
Power and supplies:			
Explosives, 40 percent gelatin dynamite, pounds per ton	0.522	0.947	1.469
Timber, board feet per ton	2.450	5.547	7.997
Total power, kilowatt-hours per ton	.....	.....	62.138
(1) Air compression	9.072	21.127	30.199
(2) Hoisting	1.864	2.237	4.101
(3) Tramming	.373	.497	.870
(4) Pumping	.....	.....	25.042
(5) Ventilation	.375	.495	.870
(6) Lighting	.....	.....	1.056
Other supplies, in percentage of total power and supplies	42.4	29.3	31.1
Power and supplies, percentage of total cost	41.8	28.8	30.6
Percentage of total mining cost	28.6	71.4	......

Table 3.—Detail of development costs in units of labor, power and supplies
Period: July 1930 to June 1931, inclusive

	Sinking		Drifting and crosscutting	Raising	Total, all development
	Shaft	Winzes			
Size of excavation, feet	8 by 20	5 by 8	6 by 8	5 by 8	....
Timbered or not	Yes....	Yes...	About 30 percent	Yes...	....
Physical properties of rock:					
(a) Hard or soft	Hard...	Hard..	Hard....	Hard...	....
(b) Firm or loose	Firm...	Firm..	Firm....	Firm...	....
(c) Swelling or running ground	Occasionally slabby				....
Advance, feet	193	46	1,881	862	2,982
Labor (man-hours per foot):					
Breaking	27.254	8.101	7.727	10.880	9.908
Timbering	14.850	1.514	1.444	1.399	2.300
Shoveling	35.465	15.482	14.767	7.172	13.922
Haulage and hoisting	9.784	12.757	12.168	13.470	12.400
Supervision	1.873	1.873	1.873	1.873	1.873
Total labor	89.226	39.727	37.979	34.794	40.403
Feet per 8-hour shift	.825	.590	1.269	.921	1.092
Power and supplies (per foot):					
Explosives, pounds	43.870	10.978	10.968	5.484	11.512
Timber, board feet	422.794	27.304	29.596	26.212	54.032
Total power, kilowatt-hours	628.585	251.433	251.435	188.578	257.679
(1) Air compression	498.468	195.363	190.355	144.506	197.130
(2) Hoisting	110.002	48.024	39.978	29.984	41.746
(3) Haulage	20.115	8.046	13.046	8.054	11.984
(4) Ventilation	....	....	8.046	6.034	6.819
Other supplies (in percentage of total power and supplies)	28.5	54.7	44.6	53.7	42.4
Labor (percentage of total cost)	57.6	60.5	57.6	60.2	58.2
Power and supplies (percentage of total cost)	42.4	39.5	42.4	39.8	41.8

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Table 4.--Detail of development cost in dollars per foot

Period: July 1930 to June 1931, inclusive

	Sinking		Drifting and crosscutting	Raising	Total, all development
	Shaft	Winzes			
Advance, feet	193	46	1,881	862	2,982
Labor (cost per foot):					
Drilling and blasting	$13.495	$ 2.540	$ 1.769	$ 2.245	$ 2.822
Timbering	7.353	.472	.329	.260	.766
Shoveling	17.561	4.852	3.388	1.341	3.736
Haulage and hoisting	4.845	3.996	2.791	2.708	2.794
Supervision	.551	.551	.551	.551	.551
Total underground labor	43.805	12.411	8.828	7.105	10.649
Surface labor charges	1.235	1.235	1.235	1.235	1.235
Total development labor	45.040	13.646	10.063	8.340	11.884
Power and supplies (per foot):					
Explosives	$10.003	$ 2.503	$ 2.501	$ 1.250	$ 2.625
Timber	11.737	.758	.822	.728	1.500
Total power	1.923	.769	.769	.577	.788
(1) Air compression	1.525	.598	.583	.442	.604
(2) Hoisting	.337	.147	.122	.092	.127
(3) Haulage	.061	.024	.040	.025	.037
(4) Ventilation	....	....	.024	.018	.020
Other supplies	9.448	4.870	3.301	2.960	3.624
Total power and supplies	33.111	8.900	7.393	5.515	8.537
Total labor, power, and supplies (per foot)	$ 78.151	$ 22.546	$ 17.456	$ 13.855	$ 20.421
Labor (percentage of total cost)	57.6	60.5	57.6	60.2	58.2
Power and supplies (percentage of total cost)	42.4	39.5	42.4	39.8	41.8

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Table 5.--Detail of stoping costs in dollars per ton

Mining methods: Open stope and pillar, cut and fill
Period: July 1930 to June 1931, inclusive
Tons of ore mined: 65,764

	Cost per ton	
Ore breaking		$ 1.321
Labor	$ 0.802	
Explosives	.216	
Supplies	.051	
Compressed air	.086	
Steel and tool sharpening	.083	
Machine repairs	.083	
Timbering		.212
Labor	.070	
Timber	.107	
Supplies	.019	
Tool sharpening	.004	
Framing and shop charges	.012	
Tramming		.164
Labor	.111	
Supplies	.017	
Shop charges	.012	
Car repairs	.022	
Power	.002	
Hoisting		.105
Labor	.074	
Supplies	.011	
Shop charges	.014	
Power	.006	
Sampling		.015
Labor	.008	
Supplies	.001	
Assaying	.006	
Pumping		.192
Labor	.108	
Supplies	.016	
Power	.068	
Miscellaneous labor charges		.033
Miscellaneous supplies		.003
Miscellaneous power		.002
Supervision		.063
Engineering		.048
Hospital expenses		.066
Housing expenses		.088
Total charges to mining		2.312

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MILLING

Capacity of Plant, and Method of Treatment

The crushing and grinding sections of the plant have a normal daily capacity of 500 tons, but the daily capacity of the flotation section is only 200 tons.

Treatment is entirely by the selective flotation method, based principally on the depressing effect of cyanide on sphalerite and pyrite. The higher galena content of Minerva ore led to a series of mill tests to determine the advisability of floating this mineral as a separate product. While this is still in an experimental stage, some lead concentrate has been produced and shipped.

As the local smelter is not adaptable to their treatment, the lead and copper concentrates are shipped to custom smelters and the zinc concentrate to Europe.

Following is a brief summary of milling and treatment practice.

Coarse Crushing

Ore is delivered from the mine to two circular, steel storage bins, 18 feet in diameter and 30 feet deep, each having a capacity of 500 tons. Through side doors near the bottom of each bin the ore passes by gravity to a 15- by 24-inch Blake jaw crusher, by which it is reduced to 4-inch size. This product is carried by a 26-inch inclined conveyor belt to the top of the mill building proper, where it is dumped directly onto inclined grizzlies, with bars spaced 1 1/2 inches apart. The grizzly oversize goes to two McCully No. 4 gyratory crushers which reduce the ore to a maximum size of 1 1/2 inches. The discharge from these crushers drops directly into the rolls storage bin, which is of wooden construction and has a capacity of 1,000 tons.

Secondary Crushing

The ore is next reduced to minus 1/4-inch size by two 42- by 16-inch Traylor rolls, working in series and crushing dry. After passing through trommels from which oversize is returned to the rolls, the ore is carried by a horizontal tripper conveyor belt, 18 inches wide, to six circular, steel bins, each 8 feet in diameter and 28 feet deep, with a total capacity of 400 tons; these form the storage for the Hardinge mill feed. An automatic sampler cuts samples for mill-heads assay and moisture determination.

Grinding

The grinding plant consists of one 8-foot by 30-inch Hardinge mill and three 8-foot by 22-inch Hardinge mills. Steel balls are used as grinding media, the larger mill being charged with 7 tons of 2-inch balls and the small mills with 5.5 tons of 1 1/2-inch balls. The ball consumption averages 3.75 pounds per ton of ore. The small mills are in closed circuit with model "B"

Dorr duplex classifiers, and the large mill is in circuit with a Dorr bowl classifier, 4.5 feet by 18 feet with 6-foot bowl. The final discharge from this section is 95 percent minus 200 mesh.

Flotation

After thickening and conditioning, the pulp passes to the lead and copper section of the flotation plant. The lead roughing is done in Fagergren machines and the cleaning in Callow pneumatic cells; copper roughing is done in Kraut and Fagergren machines and the cleaning in Callow cells. Tailings from this section are pumped to a zinc conditioning tank, and from there flow by gravity to the zinc section where the roughing is done in Callow cells and the cleaning in McIntosh pneumatic machines.

Filtering

The concentrates are dewatered in Dorr thickeners of concrete construction, the thickened concentrate being removed from the tanks by Dorrco pumps, and filtered in Oliver filters. From the filters the concentrates are transported to storage bins for loading and shipment.

Costs

The following table gives detailed milling costs for the 1-year period from July 1930 to June 1931.

Table 6.—Detail of milling costs in dollars per ton

Tons of ore treated: 65,764
Period: July 1930 to June 1931, inclusive

	Cost per ton	
Coarse crushing		$0.055
Labor	$0.043	
Supplies	.008	
Power (1.445 kilowatt-hours)	.004	
Secondary crushing		.090
Labor	.046	
Supplies	.038	
Power (2.136 kilowatt-hours	.006	
Grinding		.317
Labor	.100	
Supplies	.156	
Power (22.052 kilowatt-hours)	.061	
Thickening and emulsification		.058
Labor	.043	
Supplies	.007	
Power (2.827 kilowatt-hours)	.008	
Flotation		.567
Labor	.155	
Supplies	.067	
Oil and reagents	.274	
Power (25.758 kilowatt-hours)	.071	
Filtering and storing concentrates		.119
Labor	.084	
Supplies	.014	
Power (7.602 kilowatt-hours)	.021	
Weighing, sampling, and assaying		.065
Labor	.027	
Supplies	.005	
Assaying	.033	
Disposal of tailings		.021
Labor	.013	
Supplies	.008	
Laboratory and experimental work		.031
Labor	.017	
Supplies	.001	
Power (0.063 kilowatt-hour)	.001	
Assaying	.012	
General mill expenses		.088
Labor	.069	
Supplies	.013	
Power (0.942 kilowatt-hour)	.003	
Miscellaneous	.003	
Supervision		.050
Royalties		.022
Hospital expense		.025
Housing expense		.044
Total charges to milling		1.552

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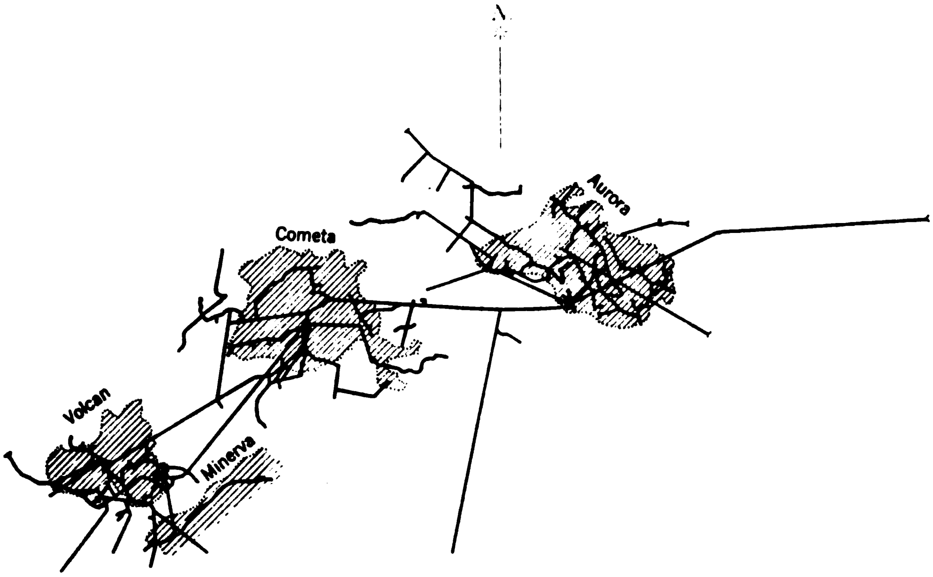

Figure 1.— Mine plan, showing position of orebodies.

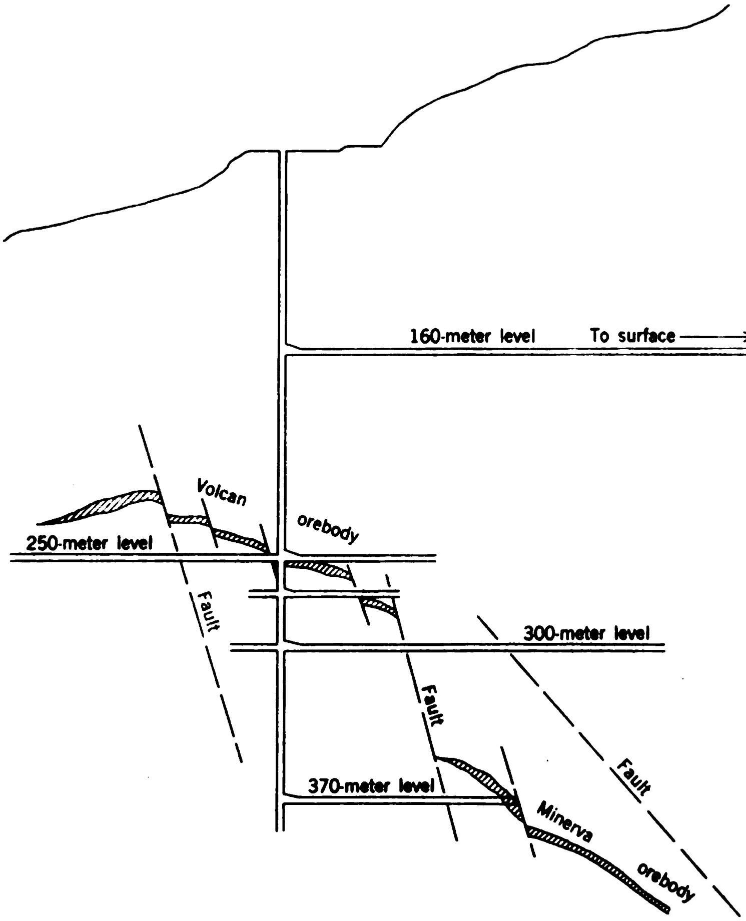

Figure 2.— Section through Minerva shaft, looking N. 54° E.

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